PLASTICS

The Story of an Industry

PLASTICS

THE STORY OF AN INDUSTRY

Prepared under the direction of the

COMMITTEE ON PLASTICS EDUCATION

of the

SOCIETY OF THE PLASTICS INDUSTRY, INC.

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FOREWORD

A PHENOMENAL RECORD of wartime service, and the promise they give of playing an increasingly important part in peacetime activities, have served to focus on plastics a worldwide interest which few products of industry have ever experienced. Persons in all walks of life have been prompted to seek information about plastics. Hundreds of questions are continually being asked, such as: What are plastics? How are they made? What will they do? Where can I get training that will fit me to enter the industry?

The limitations of a letter prevent giving satisfactory replies to these questions. Hence, the Committee on Plastics Education has prepared this booklet. It is a non-technical yet comprehensive word picture of the plastics industry which has developed since Man undertook to explore the field of chemistry.

It was learned that commonly-known, basic materials are made up of links or chains of atoms which could be broken down or combined in differing ways and that such combinations produced new materials having a wide variety of uses.

To date, about thirty basic plastic products have been developed which lend themselves to hundreds of formulations. Hence, it is possible to produce materials which are actually "tailor-made" for the purpose to which they will be put. Meanwhile, chemists and engineers are continuing their research and there is sound reason for believing they will develop many additional plastics materials which will be put to thousands of uses.

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PLASTICS - - WHAT THEY ARE

In any study of plastics, it is vitally important to keep the fact constantly in mind that the term plastics is applied to a large number of products having widely differing characteristics. The generally accepted definition of a plastic is: Any one of a large and varied group of materials which consists of, or contains as an essential ingredient an organic substance of large molecular weight and which while solid in the finished state, at some stage in its manufacture has been or can be formed into various shapes by flow usually through application singly or together of heat and pressure. Before being processed, plastics may be sheets, rods or tubes, as well as in powder, flake, granular or liquid form. Finished products are derived from these various forms through molding under heat and pressure, by casting, extrusion, machining, blowing, bonding, calendering, gluing, coating, laminating or mixing with other materials.

HISTORY AND DEVELOPMENT

The origin of plastics is another example of the age-old search for new and better materials to replace natural ones used up because of utter disregard for future needs, or to perform functions more satisfactorily than materials available. Back in 1868, when a shortage of ivory for making billiard balls existed, a prize was offered for an equally suitable material. John Wesley Hyatt, an Albany, New York, printer with an inventive turn of mind, hit upon a method of mixing cellulose nitrate, produced from cotton linters and nitric acid, with camphor. The product was named Celluloid and when found to have many uses it became the first commercially accepted plastic. In addition to its use in billiard balls, Celluloid was employed for collars, cuffs, and shirt fronts. Later, window curtains were made from it for early models of automobiles, and when colored pink, it was widely used to replace hard rubber in making denture plates.

Despite this opening of the door on the world of synthetic materials, the next fifty years brought only four developments. In 1895, a natural resin, shellac, produced by an insect found in Asia and Southern India, was utilized to make phonograph records. Today, shellac is also employed in the manufacture of high voltage insulators, records and for coatings, whereas an improved type of phonograph record is being made from plastics.

EARLY PHENOLIC EXPERIMENTS

In 1909, a major advance took place. Dr. Leo H. Baekeland, a noted Belgian chemist who had come to America, experimented with phenol (carbolic acid) and formaldehyde while seeking a better material than shellac. While others had made similar experiments, he was the first to obtain a controllable reaction and the first to exploit the commercial possibilities of this resinous material. Using greater heat and a catalyst (a substance which speeds chemical reaction but remains unchanged itself), he produced a resin that could be cast to desired form, as well as compounds that could be molded under heat and pressure into a variety of products. At this same time, he also produced laminating varnishes and worked on many other uses. In addition he incorporated other materials, known as fillers, in the molding compounds, thereby giving them improved or additional properties.

That same year, bitumin plastics, more commonly known as cold molded, were developed from asbestos, asphalts, coal tar, stearin pitches, natural and synthetic resins, and oils. A heat-resistant, insulating material, it is used in the electrical, wiring device and automotive fields, being molded under pressure at or near room temperature to desired shape, then baked in ovens to insure holding of that shape.

In 1919, casein plastic was introduced commercially in America. Originally produced in Europe about 1890, it is made from the protein of skimmilk reacted with formaldehyde.

MANY ADVANCES SINCE 1925

About twenty new plastic compositions which are described later, have been developed or introduced commercially and a tremendous increase in the annual production of plastics has taken place. The order in which these new plastic resins have appeared is:

1926 – Alkyd
Aniline-Formaldehyde

1927 – Cellulose Acetate

1930 – Urea-Formaldehyde

1931 – Acrylic

1932 – Cellulose Acetate Butyrate

1936 – Methyl Methacrylate
Vinyl

1937 – Ethyl Cellulose
Lignin
Polystyrene
Vinyl Butyral

1939 – Melamine-Formaldehyde
Ethylcellulose
Vinylidene Chloride

1942 – Allyl
Polyethylene

1943 – Silicones

1944 – High heat-resistant thermoplastics such as styrene copolymers

WAR GAVE ADDED IMPETUS

THE APPLICATION AND USE of plastics underwent a tremendous increase when world-wide hostilities broke out. In every part of the complex war machine put into motion by the Allies, plastic products or plastic-treated materials performed vital functions. In short, military needs took more than 85 percent of the total output of the industry while a large part of the balance went into essential products. In the construction of battleships more than 1,000 different plastic applications were employed and more than 200 in producing a single airplane. Resin-bonded plywood was used in the building of the famous PT boats and mosquito bombers as well as training planes and gliders. Now, the "know-how" which produced those important items is turning out pleasure craft for peacetime use.

In answering the call for products which could "take it" in modern global warfare, the plastics industry made an enviable record. Hundreds of new uses were found for the various types of plastics and they met exacting standards set by the armed services for lightness, resistance to corrosion, transparency, low moisture absorption, flexibility even at low temperature and ability to withstand wide and sudden changes in temperature, resistance to chemicals and salt water, high tensile and impact strength and all-around serviceability in all war theaters, from the tropical jungle with its deteriorating heat and humidity to the Arctic with its biting cold and raging storms.

WIDE RANGE OF WAR USES

The war uses of plastics ranged from buttons to navigational equipment. They included such unrelated items as functional parts of shells and bombs, rockets and their components, radomes for sensitive radar equipment, radio crystal holders, salt-water purification stills, innersoles for jungle boots, goggles, assault boats, life-rafts, helmet liners, foot-tubs, fuel cells, hand grenades, waterproof covers for small arms, medical kits, binnacle stands, propellors, all-plastic binoculars, gears, bearings, housing, antenna masts and housings, electrical equipment parts.

The truly remarkable wartime production record of the plastics industry was to a great extent the result of teamwork developed by the Society of the Plastics Industry, Inc. This headquarters of the industry acted as liaison between the Government, the armed forces and over 550 leading companies in the industry who are members of the Society.

MAKE-UP OF THE INDUSTRY

THE PLASTICS INDUSTRY is commonly regarded as consisting of four separate and distinct types of operators employing around 85,000 persons.

MATERIAL SUPPLIERS

First come the producers of plastics, who in most cases are the large chemical manufacturing companies. They supply molding compounds in powder, granular, or flake form to molders and extruders of finished products, as well as sheets, rods, tubes, films or foils to fabricators who work these into finished products. They also supply glues for the plywood and woodworking industries, and industrial resins for a wide variety of uses such as surface coatings, brake linings, grinding wheels, and impregnating resins. There are approximately 25 material suppliers and they employ about 15,000 persons. In 1944, about 450,000 tons of materials were produced and the total value of all plastics was approximately $500,000,000. Of this total, molded plastics accounted for $150,000,000.

MOLDERS

A second group consists of molders and extruders who take the molding compounds and mold them into finished products. More detailed information about their operations is given later. This group is comprised of about 650 operators whose plants are located mostly in New England, the Middle Atlantic States, Middle West, Pacific Coast, and Canada. Their operations give employment to approximately 25,000.

FABRICATORS

A third division of the industry consists of fabricators who machine finish or semi-finish products from sheets, rods and tubes, as well as special shapes. There are some 1,500 firms in this field, ranging in size from owner-operator units to those with 300 or more employees. Their plants very from those with small investment in simple equipment for the production of novelties, to those which produce complex industrial items or engage in mass production of novelties. These have highly specialized and often costly equipment. Fabricators use thousands of tons of various plastics materials and their plants constitute a large employment opportunity in the industry.

LAMINATORS

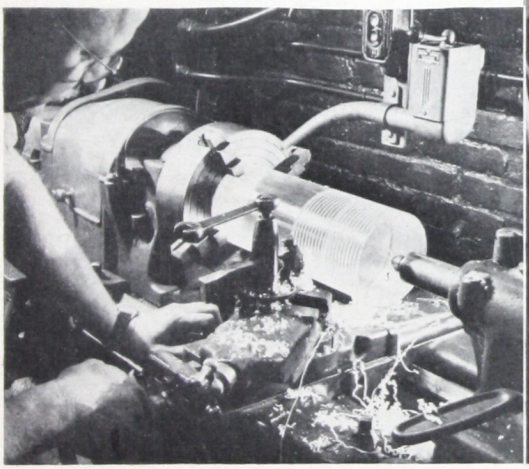
The fourth group is made up of laminators, of whom there are about 40 at the present time. These firms buy liquid resin which they use to

impregnate paper, cloth or wood, and treat glass fibres which they form into composite sheets, rods or tubes and fabricate into final form.

In addition to these major groups at present regarded as comprising the plastics industry, there are other important groups closely affiliated. Among these are textile operators who secure plastic resins with which they impregnate, colendar and coat textiles of various types to produce special finishes and provide added qualities that permit of wider uses. A third group makes "unsupported film"—pliable plastic sheeting which does not contain any textiles or other supporting materials.

Another group obtain mono-filaments (thread-like strands) of plastics and make various fabrics, while a fourth engages in the coating or treatment of paper to give it added strength and uses.

TYPICAL FABRICATING OPERATIONS
At Right: Drilling holes in sink strainer.
Below: Shaping plastics rod on lathe.

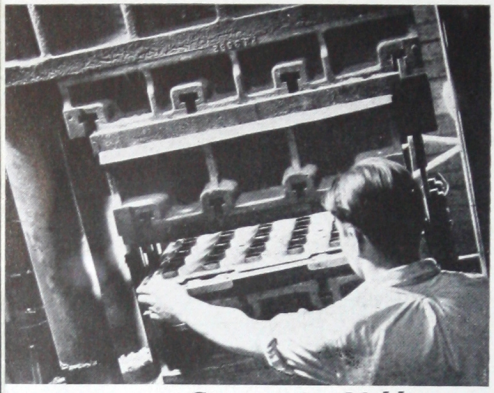


FORMING AND FABRICATING PLASTICS

A MAJOR PORTION of raw plastics materials are made into finished articles by molding or fabricating processes. On the preceding page are examples of some of the operations performed by fabricators. Brief descriptions follow of various methods of molding.

COMPRESSION MOLDING

This process is used in forming thermosetting materials into finished articles. A steel mold in the shape of the desired product is filled with



Compression Molding

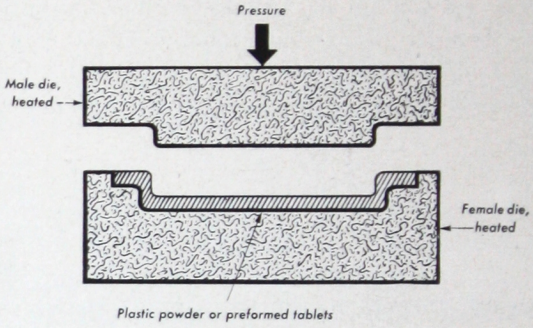


Diagram of Compression Mold

molding compound which is subjected to heat and pressure. The heat is usually provided by steam but sometimes oil or electricity are employed.

To speed up molding operations, the powder is frequently compressed beforehand into tablets or preforms which can be inserted into the mold more quickly than loose compound and also permit more accurate loading. As a further means of speeding up the process, preheating of the preforms of material is often practiced. This may be done in various ways but usually through the use of high-frequency heating units; by subjecting the preforms to the rays from a battery of infra-red lamps; or by placing them in preheating ovens. The material is heated to approach molding temperature, then the hot, soft preforms are placed in the mold for final molding and shaping.

TRANSFER MOLDING

This is basically a compression molding process used in producing articles chiefly from thermosetting molding materials. Instead of loading

compound directly into the mold cavity as is done in ordinary compression molding, in this process the material is first heated to the melting point in a transfer chamber. Then it is forced into a closed mold, by means of a hydraulically-operated plunger, where the forming and hardening process is completed. This process is usually employed where complicated parts are to be made, such as electrical devices with metal inserts. The material flows around these parts without disturbing their position, thus averting misalignment and other malformations which would necessitate rejection of the finished article as being imperfect. Plunger molding is a type of transfer molding.

INJECTION MOLDING

This process is used to form thermoplastic compounds into finished products. The great majority of thermoplastics are molded by the injection method. The procedure is to load plastic compounds into a hopper which feeds into a cylinder. Then a ram forces the compound into a heating chamber under pressures ranging up to 25,000 lbs. per sq. in. After being melted in this chamber, the compound is then forced into a cool, closed mold where it solidifies. After solidifying, the mold is opened and the part ejected.

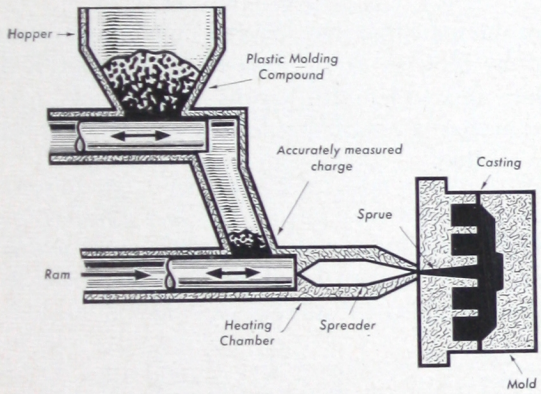
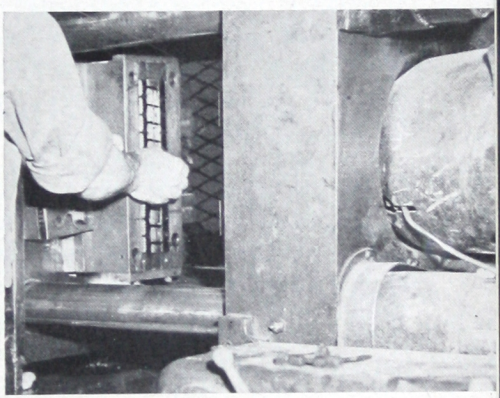


Diagram of Injection Molding



Injection Press

Injection machines of special design are sometimes used to form thermosetting materials. This process is called jet molding. Material is fed into a heating cylinder where it is preheated and then forced through a nozzle which is heated to a high temperature as the material flows through it. After a predetermined amount has been injected into the hot mold, the nozzle is immediately cooled to prevent curing of the material

which remains in the nozzle. Pressure is maintained on the compound in the mold while the cure is completed by heat supplied from the mold.

EXTRUSION MOLDING

This process is employed in forming thermoplastic materials. It consists of forcing molten material through a die of desired size and profile to form continuous sheets, rods, filaments, tubing, pipe, and wire covering.

Extrusion Molding

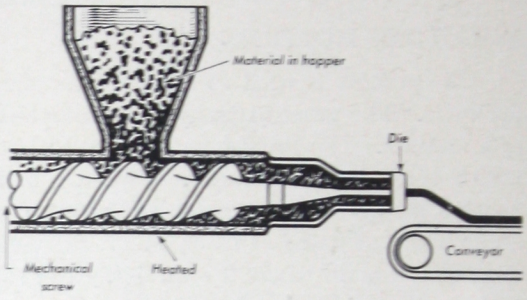


Diagram of Extrusion Molding

As the extrusions come from the machine, they are fed on to a conveyor belt where they are cooled by blowers or by immersion in water and then are ready for cutting into desired lengths. In the case of wire coating, the material is extruded around a continuing length of wire or cable and wound on drums after cooling.

COLD MOLDING

In this process, cold molding compound is forced into a mold which forms it into the desired shape. It is then removed and hardened by some external treatment such as soaking in water or baking.

CASTING

This method is employed chiefly with thermosetting phenolic resins and thermoplastics such as methacrylate. Resin-forming materials are poured into an open mold and then baked to desired hardness.

DRAWING

This term is applied in the industry to the process of stretching sheets of plastic materials over a form to obtain a desired shape, or drawing sheets of plastics materials through a die by means of a shaped plunger. The process is frequently called deep-drawing.

BLOWING

In this process, thermoplastic sheets or extruded charges are placed in closed molds and forced into shape by air or steam pressure to form articles of desired shape. Recently this method, with automatic machines for blowing, has been undergoing further development.

PULP MOLDING

This is a process similar to papier-mache making. A porous form, approximating the shape of a finished article, is lowered into a tank

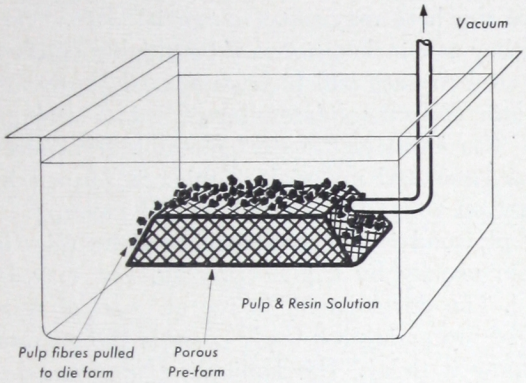
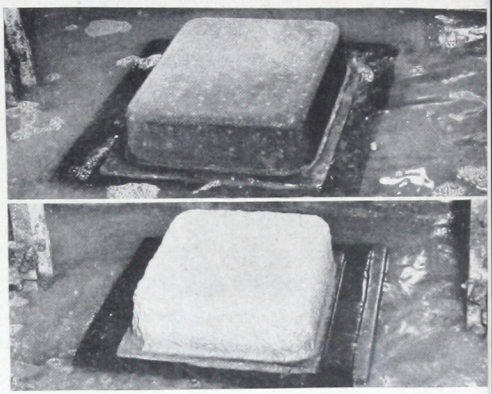


Diagram of Pulp Molding



Pulp Molding

containing a mixture of pulp, plastic resins and water. The water is drawn off through the porous form by a vacuum. This causes the pulp and resin mixture to be drawn to the form and adhere to it. When a sufficient thickness of pulp has been drawn on to the form, it is removed and then molded under pressure into final shape.

LOW PRESSURE OR CONTACT MOLDING

Low pressure or contact molding has been used extensively in aircraft production to form various parts of planes. In low pressure molding layers of coated or impregnated material are placed over a form or mold. They are then covered with a rubber bag or flexible membrane which may be subjected to hydraulic or air pressure. Layers are consolidated into a single piece in which form they are held by the resins. In the case of contact molding, layers coated with plastic are brought together and fixed in position until cured.

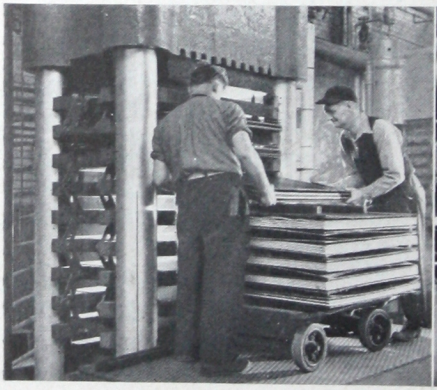
POST-FORMING

This is a process wherein finished laminated sheet material can be drawn or reformed into a desired shape by heat and externally applied pressure, in simple forming dies or fixtures.

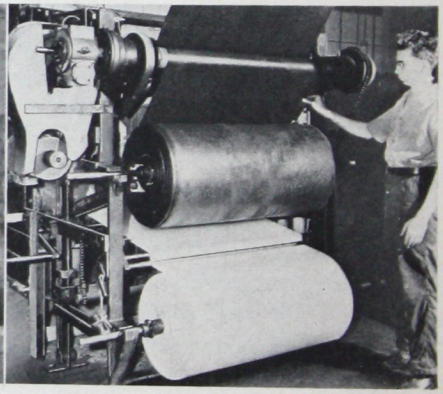
LAMINATING

In the making of laminated plastics, layers or plies of material such as cloth, paper, wood, or glass fibers, are alternated with layers of plastic resins, then pressed into a single piece. In the case of cloth or paper, a roll of fibrous material is usually drawn through an impregnating tank containing a resin solution. It is then passed slowly through an oven for evaporation of the solvent where the heat may effect a partial cure. After cutting into sheets or plies, they are stacked between two highly polished steel plates and then subjected to heat and high pressure in hydraulic presses, which cures the resin and consolidates the plies into a single piece of desired thickness. The finish of the steel plates is transferred to the outer surfaces of the laminated material. Tubing is formed by rolling the resin-treated sheet on a mandrel under heat and pressure.

The process of making plywood is similar except that the plies of wood are treated with resin usually by a glue-spreader, but may be dipped, sprayed or brushed. The development in recent years of resin glues, together with improved processing has made possible the gigantic plywood industry as we know it today. The laminating process takes longer than the molding process. Laminates are noted for their strength, the fact that they may be punched and machined, and for their electrical characteristics.



Loading Laminating Press



Impregnating Material

PLASTICS - - THE MATERIALS

PLASTICS ARE DIVIDED into two general types—thermosetting and thermoplastic resins. Thermo means heat, hence the thermosetting group are those plastics which set or harden into permanent shape when heat and pressure are applied to them. Conversely, the thermoplastic group comprises those that are softened by heat and hardened into shape by cooling.

Until recently a thermoplastic material has been unsuited for any application involving a temperature of 160° F. or higher. Recent research and experimentation in the thermoplastic field, however, indicate that in the future there may be less distinction between the two basic types.

Both of the major types mentioned above have significant characteristics. They are light in weight yet have high strength in proportion to their weight. They are warm to the touch. Many have good electrical properties and some can be produced in a wide range of colors which completely permeate finished articles.

Thermosetting plastics in general use include:

Allyl Esters
Amino
- Melamine Formaldehyde
- Urea Formaldehyde

Aniline Formaldehyde
Phenol Formaldehyde
Phenol Furfural

Thermoplastic plastics are

Acrylics
Casein
Cellulose Acetate
Cellulose Acetate Butyrate
Cellulose Nitrate
Ethyl Cellulose
Polyamides
Polyethylene
Polystyrene
Polyvinyl Alcohol
Shellac
Vinyl Acetate
Vinyl Butyral
Vinyl Chloride
Vinyl Chloride Acetate
Vinylidene Chloride

In addition to the foregoing thermosetting and thermoplastics materials, there are two plastics used for cold molding—Refractory and Non-refractory, as well as an important group of rubber-like plastics.

Thermosetting Plastics

ALLYLS

These are a distinctly new type of thermosetting plastics derived from allyl alcohol. They are the nearest approach to glass yet produced by the plastics industry and have greater surface hardness than other transparent plastics. Other characteristics include strength, flexibility and general resistance to deteriorating influences.

Trade Names: °Allymer, Kriston, MR Resins.

AMINOS

These include both urea-formaldehyde and melamine-formaldehyde. They belong in the thermosetting group and are especially noted for their pastel shades, color stability and electrical characteristics.

Melamines are one of the newer classes of thermosetting resins, closely related in composition and characteristics to the ureas. They are derived from calcium cyanamid reacted with formaldehyde. They possess excellent electrical properties, have great resistance to moisture, and good surface hardness. Like ureas, they have unlimited color range which is light-fast, and are odorless and tasteless. Typical uses are: in molded form as tableware, buttons and ignition parts; in liquid form they are widely used in the treatment of wet strength paper, crease-proofing of textiles, and to reduce textile shrinkage. They are also used as laminating resins.

Trade Names of molded Melamine are: Melmac, Plaskon, Resimene.

Ureas are derived by combining urea and formaldehyde through a condensation process and are available as molding compounds, laminating resins, glues, surface coatings, paper-treating resins and for numerous industrial uses. Many of their characteristics are similar to phenolics. They have unlimited color range and are light-fast, are odorless and tasteless, and have good resistance to acids and alkalies. Typical uses are: clock cases, scale housings, radio cabinets, lighting equipment such as commercial and floor lamp reflectors, cosmetic jars, hardware, electrical devices, buttons, tableware, electric razors, and closures.

Trade Names for urea molding materials are: Bakelite, Beetle, Plaskon and Sylplast.

° All trade names are those of raw materials produced and sold commercially. No attempt has been made to include all materials or present a complete trade listing.

ANILINE FORMALDEHYDES

This is one of the early thermosetting materials to be developed. Produced by the condensation of formaldehyde and aniline, it is not soluble in any common organic solvents nor affected by alkalies. It is especially resistant to alcohol but is affected by strong acids. It has high insulation properties and is not easily affected by weather. It is available as molding powder or in sheets and rods. The radio and television fields use it extensively, and it has many applications in aircraft, attennae housings, tube bases, terminal boards and electrical devices.

Trade Names: Cibanite, Dilectene.

PHENOLICS

These are thermosetting, synthetic compounds derived from coal tar acids and capable of withstanding much higher temperatures than most thermoplastics. They are divided into four general groups: ordinary phenolics to which fillers are added and then molded by compression or transfer; cast phenolics; casting resins, and laminating resins.

Phenolics are more widely used by molders than any other plastics, but they are also employed extensively in adhesives, paints, varnishes and abrasives, as well as for casting and laminating. By adding different types of fillers such as wood flour, chopped fabric, mica, asbestos and the like, molding compounds are produced from which an extensive array of articles with a wide variety of properties can be molded. Finished articles are light in weight, resistant to alcohol, have good surface appearance and excellent electrical properties. Familiar products include: telephone hand sets, electrical switch parts, coffee pot handles, business machine cases or housings, buttons, closures, containers, gears, and bearings.

When casting is employed as the manufacturing process, it has been found that several colors can be employed, producing unusual effects resembling marble or onyx. Cast products are resistant to average oils, acids and alcohol, also to moisture, but will soften slightly and whiten in hot water. Typical cast forms are: clock cases, tooling and forming dies, knife handles, radio cabinets, decorative trim, dice, dominoes, poker chips and costume jewelry.

Trade Names of phenolic molding compounds are: Bakelite, Durez, Durite, Indur, Makalot, Resinox.

Trade Names of casting resins include: Catalin, Durez, Marblette.

Trade Names of cast phenolics include: Bakelite, Catalin, Gemstone, Marblette, Prystal.

The Materials used in producing the articles illustrated on the following pages are:

1. *Vinyl;* 2. *Nylon;* 3. *Acrylic;* 4. *Cellulose Acetate;* 5. *Casein;* 6. *Polystyrene;* 7. *Vinylidene Chloride;* 8. *Phenolic;* 9. *Cellulose Acetate Butyrate;* 10. *Urea and Melamine;* 11. *Cellulose Nitrate;* 12. *Polyvinyl Alcohol.*

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PHENOL FURFURALS

Phenol-Furfural resins are in many ways similar in physical properties to the phenol formaldehydes. The furfurals are of special interest as they are obtained from waste farm products such as oat hulls, corn cobs, etc. Dark in color, they possess excellent moldability because of flow and curing characteristics. Typical applications are: aircraft pulleys, radio cabinets, camera parts, abrasive grinding wheels, and electrical parts.

Trade Name: Durite.

Thermosplastic Plastics

ACRYLICS

Methyl Methacrylate is an important resin of the acrylic type. It is a thermoplastic produced by treating an acetone derivative with methyl alcohol in the presence of sulfuric acid. Available in the form of sheets, rods, tubes, liquids and molding compounds, it is easily formed, odorless, tasteless and color fast. It has excellent transparency and optical properties. These made methacrylate especially useful to the military services and indicate many and varied peacetime applications. While relatively soft with a tendency toward scratching, it can be readily repaired by sanding and buffing. Typical uses are: lenses, reflectors, airplane windows and frames, dentures, surgical apparatus, dials, combs, costume jewelry, brush backs and powder boxes, where crystal clarity and color effects can be used to advantage.

Trade Names: Lucite, Plexiglas.

CASEINS

These are produced from the protein of skim milk, reacted with formaldehyde. They are available only in sheets, rods and tubes for the production of items to be cut or machined into finished form. They are easily fabricated, have good lustre and a wide color range, but absorb water readily and lack dimensional stability under long exposure to high humidity. Plastics made of agricultural products, such as soy beans, are produced by a similar means but are not expected to become commercially important until further research and experimentation has been completed. Typical uses of casein plastics are: buttons, novelty jewelry, buckles, toys and accessories.

Trade Names: Ameroid, Galorn.

CELLULOSICS

The cellulose plastics are among the leading materials used in the industry. Most of them are available in a great variety of forms, including sheets, rods, tubes, molding powders, films, textile fibres, lacquer and foil. Because they have excellent colorability and their nature permits of a wide range of formulations, it is possible to emphasize certain properties for a particular end use.

CELLULOSE ACETATE was first used about 1910 in safety photographic film, but was not available in the form of a thermoplastic molding compound until 1927. It is generally produced from a combination of cotton linters with sulphuric acid, acetic acid and acetic anhydride. Since 1934 and the development of injection molding machines, consumption of cellulose acetate plastic has increased until it now holds first place among thermoplastic molding compounds. It has fair water resistance and a limitless color range. Typical uses are: combs, novelty jewelry, toothbrushes, toys, glazing, automobile hardware and transparent containers.

Trade Names: Bakelite, Chemaco, Fibestos, Kodapak, Lumarith CA, Nixonite, Plastacele, Tenite I and Vuepak.

CELLULOSE ACETATE BUTYRATE is similar to cellulose acetate and may be injection molded or extruded. It is produced from cotton linters treated with acetic acid, acetic anhydride and butyric acid. It absorbs less moisture than cellulose acetate, requires less plasticizer for the same flow and has greater affinity for the plasticizer, thus has better dimensional stability. Typical uses are: toothbrush handles, electric clock housings, portable radio housings, flashlight cases, shower nozzles, cutlery handles, combs, steering wheels.

Trade Names: Hercose, Tenite II.

CELLULOSE NITRATE, commonly called Pyroxylin, is the earliest of the important thermoplastics. It is produced from wood cellulose or cotton linters, treated with sulphuric and nitric acids and plasticized with camphor. Cellulose nitrate materials are not available in molding compound. They are sold to fabricators in the form of sheets, rods, tubes, films and emulsions. Finished products resist corrosive action of ink, are tough, water resistant, color-fast, tasteless, and flexible. Because of their high rate of combustibility, they are not suited to applications where high heat or an open flame may be encountered. They have an almost limitless color range which permits of mottled effects and geometric color designs when desired. Typical uses are: shoe heel covers, fountain pen barrels, decora-

tive jewelry, combs, knobs, soap dishes, piano keys, spectacle frames, cutlery handles, photographic film, toothbrushes, tool handles, and ping-pong balls.

Trade Names: Amerith, Celluloid, Nitron, Nixonoid, Pyralin.

ETHYL CELLULOSE is one of the newest cellulose materials, derived by treating cotton linters with caustic soda and ethyl chloride. This product has exceptional toughness and flexibility even at extremely low temperatures, which is important with surface coatings and similar applications where this product is widely used. It is tasteless and color-fast, has good electrical properties, resistance to alkalies, weak acids and moisture. It is available in molding compounds, sheets, rods and tubes. Typical uses are: flashlights, automobile hardware, steering wheels, instrument panel assemblies, vacuum cleaner parts and electrical parts. It is also widely used in sheet form as a packaging material.

Trade Names: Chemaco, Ethocel, Ethofoil, Lumarith, Lumarith E. C. and Nixon E. C.

POLYAMIDES

Nylon is the generic term applied to this comparatively recent group of polyamides. From a chemist's viewpoint, they simulate natural proteins. Nylon has high strength and great toughness, is odorless, tasteless, has good resistance to chemicals, is easily machined, and does not deteriorate with age. Typical uses are: molded devices needing thin cross sections, extruded tubes and filaments, brush bristles of all sorts, cordage and rope, window screens, tumblers, combs and tableware.

POLYETHYLENES

This is a relatively new, flexible and translucent material which can be processed by all the methods employed with other thermoplastics — extruded, as filaments, molded, fabricated into sheets and film, and coated on cloth. It has low specific gravity, being lighter in weight than any plastics, excellent electrical properties making it valuable in electronic uses, low moisture transmission, chemical inertness, flexibility and toughness. As manufactured, the resins are colorless but can be made into translucent articles or formulated in a wide color range with high lustre. Typical uses are: insulation for wire and cable, shower curtains, packaging. This plastic is expected to share in the uses of vinyl chloride, vinylidene chloride and the polyamides because of its properties and favorable cost factors.

Trade Name: Polythene.

POLYSTYRENES

Polystyrene promises to become one of the widely used thermoplastic compounds. It is related to the vinyl resin group, but is generally distinguished from the resins in that group. It is produced from benzene and ethyl chloride and is available in sheets, rods, tubes, molding compounds and laminating varnishes. Products from it are usually injection molded or extruded. It is outstanding for electrical qualities, low water absorption, permanence of dimensions, exceptional resistance to most acids and other chemicals. It is odorless, tasteless and color-fast. Uses are instrument panels, high frequency insulation, battery cases, combs, blown bottles, refrigerator parts, bottle closures, chemical and cosmetic containers, novelty jewelry, electrical and household items.

Trade Names: Bakelite, Cerex, Chemaco, Loalin, Lustron, Polyflex, Styraloy, Styramic, Styron.

SHELLAC

Shellac, a natural resin, was one of the first molding compositions ever used in the plastics industry. It is produced by insects which draw the materials from certain species of trees in India. This resin possesses physical properties which make it an ideal plastic binder for many applications. Modern applications find shellac being used for electrical equipment, phonograph records, as an adhesive for grinding wheels, as a finishing coat for wood work and more recently as a resinous binder for cloth, paper, silk, mica and other materials.

VINYLS

The Vinyl resins are among the more recent plastic compounds to attain widespread commercial importance, being first introduced in the United States in 1928 as rigid or semi-rigid products. They were first introduced in elastomeric, plasticized form in the early 1930's. Since this introduction numerous other compounds were developed and they have become one of our versatile plastic families. All are thermoplastics, mainly derived from acetylene which is reacted with acetic acid or hydrogen chloride to produce the acetate or chloride groups.

Polyvinyl Alcohol is a resin which has recently gained prominence as a replacement for rubber. It is known for its oil and grease resistance as well as toughness. It can be molded into tough, elastic, rubber-like articles but is not recommended for use where a high degree of water resistance is required. Typical uses include aprons and gloves, grease-

proofing paper, printing plates, sizing of textiles, tubing and gaskets.

Trade Name: Elvanol.

VINYL ACETATE is used as an adhesive especially for the bonding of cloth, paper, card-board, porcelain, metal, mica, stone, leather, wood and glass. It is also employed as an intermediate in the synthesis of vinyl butyral and polyvinyl alcohol which are described below.

Trade Names: Gelva, Vinylite.

VINYL BUTYRAL is one of the polyvinyl acetals made by reacting aldehydes with polyvinyl alcohol. By varying the degree of plasticization and the types of fillers or other ingredients, it can be compounded into plastics ranging from hard, stiff molding materials to extremely soft and extensible products. It can also be made in a wide range of colors, including clear transparent. Its uses include: an elastomer for fabric coatings, safety glass, for molding and extruding.

Trade Names: Butacite, Butvar, Saflex, Vinylite X.

VINYL CHLORIDE is the basic resin of high molecular weight produced from acetylene and hydrogen chloride. By plasticization its hardness and flexibility may be varied from soft gels to bone hard products. Its inherent stability makes it chemically resistant to most destructive factors. Because of its inertness however, it is difficult to dissolve in even the best solvents. Its uses include wire insulation, shoe soles and parts, extruded belts, straps and moldings, coated fabrics, unsupported sheetings, films, rainwear, molded articles, toys and novelties. It may be colored and compounded to obtain a range of physical and chemical characteristics.

Trade Names: Chemaco, Geon, Vinylite.

VINYL CHLORIDE ACETATE is a combination of vinyl chloride and vinyl acetate in which the best properties of each are retained. Well-known products made from it include suspenders, shower curtains, wire insulation, shoe soles and tipping, cosmetic containers, waterproofed fabrics, rainwear, tobacco pouches, and recordings for broadcasts. It is available in a wide range of colors and many properties.

Trade Name: Vinylite.

VINYLIDINE CHLORIDE is another recent development combining many of the best properties of each of the base materials but also obtaining certain unexpected results. Whereas its chemical and physical properties are closely allied with those of polyvinyl chloride its solubility is greater in the better solvents and its processing temperatures are lower. Its primary applications are for coated fabrics, unsupported sheetings,

film, extruded and molded articles. It may be plasticized and colored in much the same way as polyvinyl chloride. When injection molding is employed, typical products are valve seats, acid dippers, filter parts and nozzle tips.

Trade Names: Geon, Saran.

Rubber-like Plastics

In addition to the materials commonly used for molding, fabricating and laminating, as well as treating or making textiles, there are rubber-like products. These synthetic rubbers are: Buna N type or GR-A rubbers, Buna S or GR-S rubbers, Neoprene or GR-M, Butyl or GR-I, and Thiokol.

Buna N is similar to natural rubber in mechanical properties and is almost unaffected by oils. It has the property of remaining flexible at extremely low temperatures and of resisting aging at high service temperatures. It can be vulcanized with less sulfur than natural rubber. When fillers are used, it acquires added properties which make it resistant to vegetable fats and oils, inks, paints, dyes. Common uses include: carburetor diaphragms, self-sealing fuel tanks, aircraft and gasoline hose, gaskets and seals, machinery mountings, abrasive wheels, printing rolls and truck tires.

Buna S has comparable resistance to aging and abrasion of natural rubber but lacks the flexing qualities. It can be readily molded or used to insulate wires and cables which must withstand high temperatures and rough handling.

Neoprene has high tensile strength, resilience, elasticity and abrasion resistance. It performs the functions of rubber under conditions where the latter would not last. Typical uses are: transmission belts, printing rolls, insulation, aprons, shoe soles.

Butyl is extremely resistant to deterioration by ozone and chemicals. It is more difficult to vulcanize than the buna rubbers and cannot be converted to hard rubber. It has excellent electrical properties, resistance to flexing, and good tensile strength. Common uses are: life-rafts, pontoons and inner tubes.

Thiokol, which is produced in four types, is chemically unlike and considerably inferior to rubber. It cannot be vulcanized with sulfur, but it is resistant to oils and solvents of the group of synthetic rubbers now available.

EMPLOYMENT OPPORTUNITIES

DESPITE THE WIDESPREAD ATTENTION deservedly achieved by plastics, and the good prospects confronting the industry as a whole, it is only right and proper to state that the "hundreds of openings" blithely claimed by uninformed writers and proponents of some educational enterprises, do not exist. However, healthy growth on the part of the industry, with an accompanying increase in the number of persons employed in it as well as engaged in supplying the industry or marketing its products, will most assuredly take place.

The large number and wide variety of plastics materials and the uses to which they may be put, naturally create many interesting jobs and occupations. Being closely related to the chemical industry, many of the operations are similar but, as is true in all industries, there is no short-cut to specialized training. While experience in working with plastics is helpful in obtaining a job in the industry, primary qualifications for specialized or technical tasks are basic fundamental engineering and chemical training.

NATURE OF OPENINGS

Opportunities in the plastics industry are similar to those in other industries and call for different levels of training, but there is room for employees who wish to work from the ground up.

As previously indicated, the material manufacturers are usually chemical companies. It naturally follows, therefore, that many of the openings they have call for training, particularly in the fields of chemical and mechanical engineering. They employ research and laboratory workers, plant operators and technical salesmen, as well as technicians qualified by experience to be production superintendents, engineers and advisors to makers of finished plastics products. However, these companies also employ numerous unskilled workers for mixing, rolling, blending and grinding operations. Most of these jobs can be learned in three to twelve months, while about 20 per cent of the others can be learned in a month or less.

The molding division of the industry employs the largest number of workers. These include operators of the various types of presses and other equipment used in the plants, as well as finishers, inspectors, mold and product designers, engineers, draftsmen, foremen and production superintendents, sales and office personnel. Mold and product designers require an intimate knowledge of the properties of plastics materials, of

available press equipment, of costs and particularly of market possibilities and customers' requirements. Experience has proven that three months to a year of training are required before an employee becomes a competent press operator and increasing lengths of training time and experience are required in the more skilled operations.

Mold-makers employed by molding firms or companies which make equipment for the plastics industry, are tool-makers by training and need to be experienced in the special skills of the plastics molder. Both mold and die makers are now greatly in demand and as the industry grows there will be steady need for men with sound tool-making experience and training. There will also be opportunities for men competent to design, build and service the various types of machines used by the industry.

Press operators in the molding division are classed as semi-skilled workers who have acquired experience in the proper operation of compression, injection, extrusion and transfer molding presses. Finishers are workers who take roughly completed articles as they come from presses and finish them for sale by such operations as polishing, filing, and sanding. Because the molding plants commonly use various materials in making their products, rigid systems of inspection are required. These call for supervisors of operations such as foremen or production superintendents who are familiar with the various plastics and their properties and are competent to determine whether satisfactory articles are being produced.

FABRICATORS HAVE VARIOUS OPERATIONS

Fabricators of plastics materials employ a wide variety of workers and presently have the most openings. The duties of their employees are similar to those in a wood-working or light metal production plant. They use bending, beading, buffing, painting and sanding operators as well as personnel which can operate such machines as saws, drills, lathes and foot presses. They also have tool and jig makers, machinists, assemblers and finishers. Fabricators regularly supply industrial and electrical firms, stores, equipment manufacturers and others with plastics products, and therefore employ engineers, draftsmen, designers and sales personnel who are on the alert for possible new applications of plastics products and competent to produce them.

In the laminating field, engineers, chemists, draftsmen and designers are employed in the development and production of various types of products, as well as sales staffs capable of determining uses and outlets for products. In the plants, workers engage in such operations as treating layers or plies of material such as cloth, paper, wood or glass, with plastics resins and in pressing these into sheets or winding them upon mandrels

under heat and pressure to form tubing. Operators of laminating presses usually need six to twelve months training, but those engaged in making products such as plywood require one or two years of training before being regarded as competent.

The treating of fabrics with plastics to obtain special finishes or qualities and the manufacture of fabrics from plastics filaments are among the newer developments in the industry. In this field, employers have need for personnel acquainted with textiles as well as with plastics materials. They naturally require designers and sales staffs which can foresee and develop outlets as well as products. In their plants, they employ workers familiar with various types of textiles and capable of operating the machines used in the treating or manufacture of fabrics.

In plastics plants there is little variety in the work performed by an employee. Mold-makers remain as such, as do press operators, finishers, inspectors and many others. However, there is opportunity to advance if ability warrants a step-up. Further, employment is not seasonal nor is it considered hazardous.

EDUCATION IMPORTANT

From the foregoing it should be apparent that engineering training (mechanical or chemical) is a distinct asset to those seeking the better paying jobs in the plastics industry. However, some of these can be attained by taking courses of instruction in schools and by reading books on plastics and their production which are obtainable in many libraries, thereby obtaining the knowledge required to hold such positions. It is also apparent that training in design also has its benefits. The plastics industry is continually introducing new products, including textiles, and effective design is important in building and holding consumer acceptance. This field particularly holds possibilities for young women with ability and imagination.

The impression should not be gained that the plastics industry has no openings for those with only grammar or high school training. As previously indicated it employs many who have not gone farther. Persons having such schooling can fit themselves for positions in the industry or to climb into better paying jobs by taking the courses given in various trade and vocational schools and supplementing this instruction by reading books and other material about plastics which is available.

For veterans seeking to enter the plastics industry, there is an "On-The-Job" Training Plan, details of which are obtainable from the Veterans' Administration. This plan permits qualified veterans to learn various phases of the plastics industry and to be paid while learning.

PLASTICS AND THE FUTURE

SPEAKING GENERALLY, the plastics industry faces a bright future. Wartime pressures and demands speeded up general recognition of the fact that plastics can be put to many and varied uses, often proving superior to materials previously considered irreplaceable. Research and experimentation are now being directed toward peacetime applications and many new, important uses are assured. Plastics now known, undoubtedly will come in for greater utilization and for special uses. Chemists will develop numerous new types with properties excelling those presently available.

PLASTICS TO HAVE FAR-FLUNG EFFECT

A leading executive in the plastics industry recently declared: "the field for plastics is like something alive. No one can tell from one moment to another what is being made from these materials, for as their properties and possibilities are understood by an increasing number of people, they are applied in an increasing variety of uses. To me, plastics constitute a sort of beneficent growth within the body of industry. A large part of the manufactured goods of the future are going to depend for their satisfactory functioning upon the plastics components that are used in them. In some cases, they will outmode other materials, but in most cases they will make new designs and new performance possible because of their unique properties. This factor should be encouraging, not only to those in the plastics industry but to all industry and to all peoples in every walk of life. The welfare of the United States in the future is going to be dependent upon the ability of those who manage industry and those who possess creative minds, to produce new and novel facilities for living that outmode the old."

Another executive comments: "Plastics constitute another milestone along the march of civilization. They mark the entry into industrial, office and home circles of an entirely new array of items. The wide scope and utility of their applications exceed those of any other products of industry. To be sure, they have their limitations, but the horizons of the industry are limited only by the resourcefulness and ingenuity of those in it. They firmly believe that *'Plastics make a better world.'*"

EDUCATIONAL FACILITIES

INSTRUCTION IN PLASTICS is a part of the curricula of many schools, colleges and universities throughout the United States and Canada, according to a recent survey. Others not now giving instruction in plastics report that they plan to undertake such courses as part of chemical or mechanical engineering instruction but are not yet prepared to announce their introduction due to the many problems of post-war adjustment. A list of these schools, showing the extent to which they give instruction in plastics, is given below. If more detailed information is desired, it may be obtained by writing the Registrar of the particular school.

The following schools have indicated that they provide instruction in plastics. The extent of this instruction is shown by the key letters and numbers after the name of each institution.

KEY: A1 – has separate course in plastics
A2 – provides instruction as part of another course
C – indicates instruction under direction of Chemistry Dept.
M – indicates instruction under direction of Engineering Dept.
B1 – gives instruction in material manufacturing
B2 – gives instruction in molding
B3 – gives instruction in fabricating
B4 – gives instruction in laminating
B5 – gives instruction in design
B – gives instruction in all foregoing operations
T – Trade School

ALABAMA

Alabama Polytechnic Institute A2C
Auburn, Alabama

University of Alabama A2C
University, Alabama

ARKANSAS

University of Arkansas A2C
Fayetteville, Arkansas

CALIFORNIA

California Institute of Technology A2C
Pasadena, California

Fresno State College A2C
Fresno, California

Plastics Industries Technical Institute T
Los Angeles, California

College of the Pacific A2C
Stockton, California

Santa Barbara State College A2M
Santa Barbara, California

Stanford University A2C
Stanford Univ., California

University of California A2C
Berkeley, California

University of Southern California A2C
Los Angeles, California

COLORADO

State College of Agricultural and Mechanical Arts A2M; B3, 5.
Fort Collins, Colorado

University of Denver A2C
Denver, Colorado

DELAWARE

University of Delaware A2C
Newark, Delaware

FLORIDA

University of Florida A2C
Gainesville, Florida

GEORGIA

Emory University A2C
Atlanta, Georgia

Georgia School of Technology A2C
Atlanta, Georgia

ILLINOIS

Illinois Institute of Technology A1
Chicago, Illinois

Northwestern University A2C
Evanston, Illinois

University of Illinois A2C; B1
Urbana, Illinois

INDIANA

Indiana Technical College A1; B
Fort Wayne, Indiana

Indiana University A2C
Bloomington, Indiana

IOWA

Iowa State College of Agricutural and Mechanical Arts A1C; B1, 2, 3, 4.
Ames, Iowa

Iowa State University A2C; B1, 2, 5.
Iowa City, Iowa

KANSAS

Kansas State College A2C; B1
Manhattan, Kansas

University of Wichita A2C
Wichita, Kansas

KENTUCKY

University of Louisville A2C
Louisville, Kentucky

MAINE

University of Maine A1; B1, 2, 3, 4
Orono, Maine

MARYLAND

Johns Hopkins University A2C; B1, 2, 4, 5
Baltimore, Maryland

University of Maryland A2C; B1
College Park, Maryland

MASSACHUSETTS

Lowell Technical Institute A2C
Lowell, Massachusetts

Massachusetts Institute of Technology A2C
Cambridge, Massachusetts

Technical School for Plastics, Inc. T
Boston, Massachusetts

Tufts College A2C; B1
Medford, Massachusetts

Worcester Polytechnic Institute A2C; B1
Worcester, Massachusetts

MICHIGAN

Michigan College of Mining A2C
Houghton, Michigan

Michigan State College A1; B1, 2, 3, 4
East Lansing, Michigan

University of Michigan A1; B1, 2, 3, 4
Ann Arbor, Michigan

Wayne University A1; B
Detroit, Michigan

MINNESOTA

University of Minnesota A1; B1
Minneapolis, Minnesota

MISSISSIPPI

University of Mississippi A2C
Oxford, Mississippi

MISSOURI

Washington University A1
St. Louis, Missouri

NEBRASKA

University of Nebraska A2M
Lincoln, Nebraska

NEW JERSEY

Princeton University A1; B
Princeton, New Jersey

Rutgers University A2C
New Brunswick, New Jersey

Stevens Institute of Technology A2C; B1, 2
Hoboken, N. J.

NEW YORK

Brooklyn College A2C
Brooklyn, New York

Brooklyn Polytechnic Institute C2M2
Brooklyn, N. Y.

Buffalo University A2C
Buffalo, New York

College of the City of New York A2C; B2, 4
New York City, New York

Columbia University A1; B1, 3, 5
New York City, New York

Cooper Union A2C; B1, 5
New York City, New York

Cornell University A2C; B1, 2, 3, 4
Ithaca, New York

Long Island University A2C
Brooklyn, New York

New York Technical Institute T
New York City, New York

New York University A2C
New York City, New York

Plastics Industries Technical Institute T
New York City, New York

Rensselaer Polytechnic Institute A1; B1, 2, 3, 4
Troy, New York

St. Lawrence University A2C; B1, 2, 3, 4
Canton, New York

Syracuse University A1C; B1, 2, 3, 4
Syracuse, New York

University of Rochester A2C; B1, 2, 3, 4
Rochester, New York

OHIO

Case School of Applied Science A1; B1, 2, 3
Cleveland, Ohio

John Carroll University A1; B
Cleveland, Ohio

Kent State University A2C
Kent, Ohio

Ohio State University A2C
Columbus, Ohio

University of Akron A2C; B2
Akron, Ohio

University of Toledo A2M; B1, 2, 3
Toledo, Ohio

Western Reserve University A2C
Cleveland, Ohio

OKLAHOMA

University of Oklahoma A2M; B1, 2, 4
Norman, Oklahoma

Oklahoma Agricultural & Mechanical College A1:B
Stillwater, Okla.

OREGON

Oregon State College A2C
Corvallis, Oregon

PENNSYLVANIA

Carnegie Institute of Technology A2C; B1
Pittsburgh, Pennsylvania

Drexel Institute of Technology A2C
Philadelphia, Pennsylvania

Franklin & Marshall College A2M
Lancaster, Pennsylvania

Lafayette College A2C; B1, 2, 4
Easton, Pennsylvania

Lehigh University A2C
Bethlehem, Pennsylvania

Mellon Institute of Industrial Research A2C
Pittsburgh, Pennsylvania

Pennsylvania State College A2C
State College, Pennsylvania

Temple University A1; B
Philadelphia, Pennsylvania

University of Pennsylvania A2C
Philadelphia, Pennsylvania

University of Pittsburgh A2C
Pittsburgh, Pennsylvania

Ursinus College A2C; B
Collegeville, Pennsylvania

SOUTH CAROLINA

University of South Carolina A2M; B1, 2, 5
Columbia, South Carolina

TENNESSEE

University of Chattanooga A2C
Chattanooga, Tennessee

University of Tennessee A2M; B1
Knoxville, Tennessee

TEXAS

Southern Methodist University A2M; B5
Dallas, Texas

Texas Agricultural & Mechanical College A2C; B1, 2, 3, 4
College Station, Texas

Texas College of Arts & Industries A2C
Kingsville, Texas
University of Texas A2C
Austin, Texas

UTAH

University of Utah A2C; B1
Salt Lake City, Utah

VIRGINIA

Virginia Polytechnic Institute A1; B1, 2, 3, 4
Blacksburg, Virginia

WEST VIRGINIA

West Virginia University A2C
Morgantown, West Virginia

WASHINGTON

University of Washington A2C
Seattle, Washington
Whitman College A2C
Walla Walla, Washington

CANADA

BRITISH COLUMBIA

University of British Columbia A2C
Vancouver, British Columbia

MANITOBA

University of Manitoba A2C; B1
Winnipeg, Manitoba

ONTARIO

Queens University A2C; B2
Kingston, Ontario
University of Toronto A2C; B2, 3, 4
Toronto, Ontario
Central Technical School T
Toronto, Ontario

QUEBEC

McGill University, Montreal A2C
Montreal Technical School T
Montreal, Quebec

TRADE PAPERS

CANADIAN PLASTICS, 341 Church Street, Toronto, Ontario, Canada.
INDUSTRIAL PLASTICS, 2460 Fairmount Boulevard, Cleveland 6, Ohio.
MATERIALS AND METHODS, 330 West 42nd Street, New York, N. Y.
MODERN PLASTICS, 122 East 42nd Street, New York 17, N. Y.
PACIFIC PLASTICS, 124 West 4th Street, Los Angeles, California.
PLASTICS, 185 North Wabash Avenue, Chicago 1, Illinois.
PLASTICS WORLD, 551 Fifth Avenue, New York, N. Y.
PLASTICS AND RESINS INDUSTRY, 299 Madison Avenue, New York 17, N. Y.
PLASTICS REPORTER, 1214 Hyde Park Avenue, Hyde Park 36, Massachusetts.
PRODUCT ENGINEERING, 330 West 42nd Street, New York, N. Y.
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